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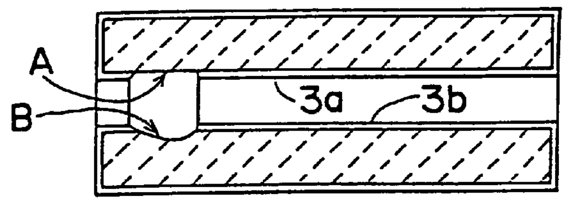
(54) Dielectric resonator and method adjusting a dielectric resonator

(57) A dielectric resonator comprises a dielectric body having at least one through hole (6), an internal conductor (3a, 3b) formed on the inside of the at least one through hole (6), and an external conductor formed on the outside face of the dielectric body, wherein the at least one through hole (6) has at least two sections of same diameter and an adjustment portion (B) free of internal conductor having a diameter different from the diameter of the at least two sections, thus separating the at least two sections by a non-conductive portion, wherein the diameter of said adjustment portion (B) free of internal conductor is larger than the diameter of the at least two sections.

Fig. 6



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Description

BACKGROUND OF THE INVENTION

The present invention generally relates to a dielectric resonator, with an internal conductor being formed within a dielectric, and an external conductor being formed on the outside face of the dielectric, and its characteristic adjusting method.

A dielectric resonator, where a resonator electrode is formed within a dielectric block, an earth electrode is formed on the outside face of the dielectric block, and a so-called tri-plate type of dielectric resonator with strip lines being opposite to each other by the use of a dielectric basic plate with a strip line being formed on one main face, and an earth electrode being formed on the other main face are used as a band passing filter and so on in, for example, the microwave band.

Fig. 31 shows as an explosive perspective view the construction of the conventional general dielectric resonator using the dielectric block. In Fig. 31, reference numeral 40 is approximately six-face unit shaped dielectric block with three internal conductor shaped holes 46, 47, 48 and coupling holes 49, 50 being provided among the respectively internal conductor formed holes. The internal conductor is formed on the inside face of the internal conductor formed holes 46, 47, 48, and an external conductor is formed on the other five faces except for an open face 52. Reference numerals 53, 54 are so-called resin pins each being composed of resin portions 53a, 54a and signal input, output terminals 53b, 54b. Two resin pins 53, 54 are inserted into the internal conductor formed holes 46, 48 from the open face side of the dielectric block so that the terminals 53b, 54b are coupled in capacity to the internal conductor within the internal conductor formed holes 46, 48. Reference numeral 55 is a case for retaining the dielectric block 40 and the resin pins 53, 54 and also, covering the open face portion of the dielectric block. The resin pins 53, 54 are respectively inserted into the dielectric block 40 so as to cover the case 55, and also, the whole is integrated by the soldering of the dielectric block 40 with the external conductor 51. In the mounting operation of the dielectric resonator, the projection portions 55a, 55b of the case 55 are functioned as an earth terminal.

As shown in Fig. 31, many components such as input, output terminals, case and so on are necessary if a plurality of resonators are formed on a single dielectric block. The assembling steps thereof become complicated and also, completed products have to be mounted as electronic components with a lead wire attached to it having to be mounted even in the mounting operation of the completed product on the circuit basic plate. The surface mounting operation can not be effected as in the other electronic components to be mounted on the same circuit basic plate so that a lower height operation is hard to effect. If the case 55 is adapted not to be used by the direct connection of the external conductor 51 of the dielectric block 40 on the earth electrode on the circuit basic plate, the open face 52 is exposed, and the electromagnetic field leakage is caused in this portion. When the metallic member approaches to the open face, the influences by the metallic member is received. Also, the resonator is connected with the electromagnetic field of the outside so that the given characteristics as the dielectric resonator can be obtained no more.

WO-A-8302853 relates to a ceramic band pass filter which includes a block which is comprised of a dielectric material which in turn is covered or plated with an electrically conductive material. The block includes holes which extend from the top surface to the bottom surface thereof. These holes are plated with electrically conductive material. The conductive plating on the dielectric material extends partially into the through hole leaving a part of the hole unplated.

JP-A-57013801 relates to an interdigital band-pass filter in which a hollow gap is made in the center of an inductive body wherein a metallic film is adhered to a proper depth on the internal wall of the hole to form a resonator.

WO-A-8500929 relates to a microwave circuit device and its fabrication. A band-pass filter is formed of a solid block of a high dielectric constant material provided with a number of holes wherein the block and the hole walls are plated with a material having an electrical conductivity much higher than that of the material of the block. The plated exterior surface of the block comprises a resonance cavity for the device and the plated walls of the through holes form a plurality of interdigital resonator rods extending into the cavity from opposite walls.

Starting from this prior art, it is the object of the present invention to provide a dielectric resonator having improved characteristics and a method for adjusting the tip end capacity of a dielectric resonator.

This object is achieved by a dielectric resonator according to the claims 1 and 2 and by method according to claims 20 and 21.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features of the present invention will become apparent from the following description of preferred embodiments with reference to the drawings, in which:

Fig. 1 is an explosive perspective view of a dielectric resonator in accordance with an embodiment;
Fig. 2 is a perspective view of the dielectric resonator in Fig. 1;
Fig. 3 is a sectional view of the dielectric resonator in Fig. 1;
Fig. 4 is a sectional view of the dielectric resonator in Fig. 1;
Fig. 5 is a sectional view of the dielectric resonator

in Fig. 1;

Fig. 6 is a sectional view of a dielectric resonator in accordance with a second embodiment;

Fig. 7 is a sectional view of a dielectric resonator in accordance with a third embodiment;

Fig. 8 is a sectional view of the dielectric resonator in accordance with the third embodiment;

Fig. 9 is a view showing the shape of a grindstone;

Fig. 10 is a view showing the shape of a grindstone;

Fig. 11 is a perspective view of one dielectric basic plate for constituting the dielectric resonator in accordance with a fourth embodiment;

Fig. 12 is a sectional view of the dielectric resonator in the fourth embodiment;

Fig. 13 is a sectional view of the dielectric resonator in accordance with the fourth embodiment;

Fig. 14 (a), (b) are a perspective view and a sectional view of the dielectric resonator in a fifth embodiment of the present invention;

Fig. 15 is a perspective view of a dielectric resonator of a sixth embodiment of the present invention;

Fig. 16 (a), (b) are a perspective view and an essential portion sectional view of a dielectric resonator of a seventh embodiment;

Fig. 17 (a), (b) are a perspective view and an essential portion sectional view of a dielectric resonator of an eighth embodiment;

Fig. 18 (a), (b) are a perspective view and an essential portion sectional view of a dielectric resonator of a nineth embodiment;

Fig. 19 (a), (b) are a perspective view and an essential portion sectional view of a dielectric resonator of a tenth embodiment of the present invention;

Fig. 20 is a perspective view of a dielectric resonator of an eleventh embodiment thereof;

Fig. 21 is a perspective view of a dielectric resonator of a twelveth embodiment thereof;

Fig. 22 is a perspective view of a dielectric resonator of a thirdteenth embodiment of the present invention;

Fig. 23 is a perspective view of a dielectric resonator of a fourteenth embodiment thereof;

Fig. 24 is a sectional view of a dielectric resonator of Fig. 23;

Fig. 25 is a front view of the dielectric resonator in accordance with a further embodiment;

Fig. 26 is a front view showing a conductor deleted embodiment for the characteristics measurement of the dielectric resonator of Fig. 25;

Fig. 27 is a partial front face view showing the conductor deleted embodiment for the characteristics measurement of the dielectric resonator of Fig. 25;

Fig. 28 is a graph showing the measurement result in the coupling coefficient changes of the dielectric resonator of Fig. 25;

Fig. 29 is a graph showing the measurement result in the resonance frequency changes of the dielectric resonator of Fig. 25;

Fig. 30 is a front face view of a dielectric resonator in accordance with a further embodiment; and

Fig. 31 is an explosive perspective view of a conventional resonator.

DETAILED DESCRIPTION OF THE INVENTION

Before the description of the present invention proceeds, it is noted that like parts are designated by like reference numerals throughout the drawings.

The construction of the dielectric resonator and its characteristic adjusting method thereof will be described hereinafter with reference to Fig. 1 through Fig. 5.

Fig.1. is an explosive perspective view of the dielectric resonator. In Fig. 1, reference numerals 1a, 1b are respectively dielectric basic plates. The semicircular two line grooves in section are formed respectively on one main face of the dielectric basic plates 1a, 1b and the internal conductor is formed on its inside face. Reference numerals 2b, 3b are internal conductors provided on the side of the dielectric basic plate 1b. Hollows 7a, 8a, 7b, 8b are respectively formed in one open of the grooves of the dielectric basic plates 1a, 1b. An external conductor 4a is provided on the main face and four side faces opposite to the internal conductor formed face of the dielectric basic plate 1a, an external conductor 4b is provided on the main face and the four side faces opposite to the internal conductor formed face of the dielectric basic plate 1b. Signal input, output electrodes 9, 10 are formed in one portion within the formed region of the external conductor 4a of the dielectric basic plate 1a.

Fig. 2 is a dielectric resonator before the characteristic adjustment with two dielectric basic plates shown in Fig. 1 being connected oppositely in internal conductors. Circular shaped internal conductor formed holes 5, 6 are constructed by the combination of semi-circular shaped grooves in this manner. Such step shaped hollows 7, 8 as shown are constructed by the hollow combination formed on one open face. The dielectric resonator shown in Fig. 2 is mounted in surface with the top face shown in the drawing being in contact against the basic plate for mounting use after the characteristic adjustment.

Fig. 3 is a sectional view through which the internal conductor formed hole 6 of the dielectric resonator shown in Fig. 2 extends.

Lines on the connection face of the dielectric basic plate are omitted (the views for reference are also the same in the subsequent description) because of the avoidance of the complicated views.

Fig. 4 and Fig. 5 are two embodiments where an open portion is formed in one portion of the internal conductor and the resonator characteristics are adjusted. In Fig. 4 reference characters A are locations where the respective one-portions of 3a, 3b are deleted near the hollow formed portions. Concretely, grinding tools such as Ryta with a grindstone shaped as shown in reference numeral 11 being mounted are used. The deleted portion is made an open portion with one portion of the internal conductor being deleted in this manner. As the deleted portion A of the internal conductor is formed in a location secluded from the open face F, the electromagnetic field leakage is restrained with respect to the interior from the open face F, or the resonator is hardly influenced by the electromagnetic field of the resonator periphery. If an metallic unit exists near the open face F, the characteristics are not disturbed by the influences from the metallic unit. When the adjusting operation is effected with the use of such a grinding tool as shown in Fig. 4, the deletion amount of the internal conductors 3a, 3b is controlled by the insertion depth of the grinding tool so that the tip end capacity is adjusted. As the resonator frequency and the coupling degree of its adjacent resonator changes if the tip end capacity changes, the given resonator characteristics are obtained by the insertion depth adjustment of the grinding tool with respect to the internal formed hole. As shown in Fig. 4, the tip end capacity to be formed in the open portion of the internal conductor is large so that the coupling degree between the resonators is made large so as to easily make the band broader.

Fig. 5 shows the other adjustment characteristic method. In Fig. 5, reference characters B are locations where the dielectric have been deleted together with the internal conductor near the hollow formed portion. A grinding tool 11 provided with a grindstone having a scoop diameter larger than the inside diameter of the internal conductor formed hole is used so as to grind the dielectric together with the internal conductor in this manner. Accordingly, the grinding tool is inserted in an axial direction from the hollow formed portion with the grinding tool being set to the central shaft of the internal conductor formed hole so that the dielectric together with the internal conductor can be easily ground by a fixed amount.

(Second Embodiment)

Fig. 6 shows a sectional view of a dielectric resonator in accordance with a second embodiment. In Fig. 6, reference characters A, B show the deleted locations of the internal conductors. One portion of the internal conductor is ground near the open face of the internal conductor formed hole and in a location secluded from the opening face so that the open portion of the internal conductor is formed in a location secluded from the open face. Accordingly, the problem caused by the electromagnetic field leakage is removed. The grinding tool provided with a grindstone of comparatively small diameter is used for formation and adjustment of such open portion so that an inserting operation and a boring operation have only to be effected obliquely from the open portion. At this time, one portion of the dielectric is together ground and the tip end capacity can be adjusted by the depth thereof.

(Third Embodiment)

The construction of the dielectric resonator and its characteristic adjusting method in a third embodiment will be described hereinafter in accordance with Fig. 7, Fig. 8.

Fig. 7 is a sectional view in an internal conductor formed hole portion of the dielectric resonator. The basic construction is different from the first embodiment although it is almost similar to the construction of Fig. 1 and Fig. 2, and the throttle portion 13 is formed in one open portion of the internal conductor formed hole. Internal conductors 3a, 3b are formed on the inside face of the internal conductor formed hole and external conductors 4a, 4b are provided on the outside face of the dielectric resonator as shown in Fig. 7. A conductor film continuous to the external conductor from the internal conductor is formed even on the inside face of the throttle portion 11.

Fig. 8 is a view sowing am example of formation of an open portion and an adjusting method. In Fig. 8, reference characters A are the deleted locations of the internal conductor and the dielectric. One portion of the internal conductor is deleted on the internal conductor shaped hole side of the throttled portion 13 in this manner, and the open portion of the internal conductor is formed in a location secluded from the open face. Therefore, the electromagnetic field leakage is restrained. In order to form such an open portion so as to effect the characteristic adjustment, a grindstone of Ryta is inserted from an opening portion where the throttle portion is not formed from the open portion of the internal conductor formed hole so as to adjust the grinding amount by the insertion depth thereof. The change proportion of the tip end capacity with respect to the insertion amount of the grindstone is different from the tip end shape of the grindstone. Such a shaped grindstone as shown in Fig. 9 and Fig. 10 may be used considering the efficiency and accuracy of the characteristic adjustment.

(Fourth Embodiment)

The construction and adjustment method of the dielectric resonator in accordance with a fourth embodiment will be described hereinafter in accordance with Fig. 11 through Fig. 13.

Fig. 11 is one basic plate for constituting a dielectric resonator. In Fig. 11, reference character 1b is a dielectric basic plate. Semicircular (sectional) two-line grooves are formed on one main face of the dielectric basic plate 1b with internal conductors 2b, 3b being formed on the inside face thereof. The single side of the throttle portion is formed in one portion of the groove. An external conductor 4b is formed on the other main face opposite to the internal conductor of the dielectric basic plate 1b and four side faces. A dielectric resonator is composed with the basic plate shaped the same as the basic plate being connected opposite to each other.

Fig. 12 is a sectional view thereof. In Fig. 12, reference numerals 15a, 15b constitute a throttle portion in one portion of the internal conductor formed hole. In a dielectric resonator having such a throttle portion in one portion of an internal conductor formed hole, a internal conductor formed on the inside face of the throttle portion is deleted with the use of grinding tool or the like from one open face of the internal conductor formed hole as shown in Fig. 13 so as to form an open portion in the internal conductor and effect a characteristic adjustment. In Fig. 13, reference characters A show the deleted portions hereof. The electromagnetic field leakage is restrained so as to form the open portion of the internal conductor in a location secluded from the open face in this manner. The adjusting operation is simplified, and the adjusting accuracy is also improved as the grinding range by the grinding tool and so on is restricted to the throttle portion.

Although the present embodiment has a comb line-type of dielectric resonator as an example, even an interdigital type can be similarly applied.

(Fifth Embodiment)

Fig. 14 shows an embodiment 5. Groove shaped concave portions 28 are formed in approximately parallel with the end face 22a side of the dielectric 22 on both the sides of the hole 23 with inside conductor 24 of the dielectric 22 being formed on the inside face. An outside conductor 25 is formed across the outside face whole of the dielectric 22 including the concave portion 28. Accordingly, the interval between the outside conductor 25, which becomes an earth electrode of the bottom portion of the groove shaped concave portion 28, and the inside conductor 24 becomes shorter as shown in Fig. 14 (b), so that floating capacity Cs can be easily obtained.

The concave portion 28 can work the dielectric 22 or form it by a molding operation. Accordingly, the floating capacity Cs can be obtained by the comparatively simple working operation or the molding operation. The adjustment of the floating capacity Cs (size of the floating capacity Cs) can be easily effected by the deletion of the size and depth of the concave portion 28 or one portion of the outside conductor 25.

In the comb-line type, the band width of the filter can be made larger by provision of, for example, the larger floating capacity Cs. The resonator length becomes shorter and the size can be made smaller by provision of, for example, the larger floating capacity Cs. Further, the floating capacity Cs can be easily obtained, and also, the adjustment of the floating capacity Cs can be easily effected even in the filter of the construction of interdigital coupling.

(Sixth Embodiment)

Fig. 15 shows an embodiment 6, which is different from the prior embodiment, with the groove shaped concave portion 28 being provided on the single side of the dielectric 22. Even in the embodiment, the floating capacity Cs can be easily obtained and the adjustment can be easily effected as in the prior embodiment.

(Seventh Embodiment)

Fig. 16 shows an embodiment 7. In the present embodiment, the groove shaped concave portion 28 is formed on one side face of the dielectric 22. The outside conductor 25 of the bottom portion of the concave portion 28 is approached towards the inside conductor 24 within the hole 23 of the dielectric 22 so as to easily obtain the floating capacity Cs.

The interval t between the outside conductor 25 which becomes an earth electrode and the inside conductor 24, the width w of the concave portion 28, the depth d and so on are changed so as to control the floating capacity Cs.

The coupling between the resonators can be adjusted by the adjustment of the floating capacity Cs. The passing zone of the filter can be controlled without changes. The above described floating capacity Cs can be provided larger by the concave portion 28.

The shape can be standardized, a metal mold cost and a management cost can be reduced. In the embodiment shown in Fig. 16, the concave portion 28 is formed on one side face of the dielectric 22, and can be formed on both the side faces of the dielectric 22. In this case, the floating capacity Cs can be provided larger.

(Eighth Embodiment)

Fig. 17 shows an embodiment 8. Round hole shaped concave portions 28 are opened, in the same direction, near the hole 23. The concave portions 28 are respectively formed in accordance with the holes 23. The hole may become one or may be formed by the number of the holes 23 or more. The concave portion 28 may be provided correspondingly on both the sides of the hole 23. Many concave portions 28 may be formed.

(Nineth Embodiment)

Fig. 18 shows an embodiment 9. In the embodiment, the round hole shaped concave portion 28 is formed on the side face of the dielectric 22. The outside conductor 25 of the bottom portion of the concave portion 28 is near-by in parallel to the inside conductor 24. Even in the embodiment, the concave portion 28 is formed correspondingly to the hole 23. The number of the holes 23 may be one or may be three or more. In addition, the concave portion 28 may be formed in either face of the dielectric 22.

(Tenth Embodiment)

Fig. 19 shows an embodiment 10. Taper potions 29 are formed on both the sides of the corner portion on the open face 23 of the dielectric 22. The taper portion 29 is formed so that the interval between the inside conductor 24 within the hole 23 and the outside conductor 25 as an earth electrode of the taper portion 29, and the floating capacity Cs can be easily obtained as in the above described embodiment.

The size of the floating capacity Cs can be easily adjusted by the angle of the above described taper portion 29 and the size of the taper portion 9. The taper portion 29 is formed on the angle portion of the other face so that the floating Capacity Cs may be obtained.

(Eleventh Embodiment)

Fig. 20 shows an embodiment 11 where the taper portion 29 is formed on the single side of the dielectric 22. Even in the embodiment, the floating capacity Cs can be easily obtained by the taper portion 29.

(Twelveth Embodiment)

Fig. 21 shows an embodiment 12. In the present embodiment, a taper portion 29 is formed with one portion instead of the whole face of the angle portion of the dielectric 22 being notched. In Fig. 21, a concave portion 30 with a taper portion 29 being formed is formed by only one portion. Concave portions 30 may be formed by plurality on the single side or both the sides in accordance with the respective hole 23. The number of the concave portions 30 is not restricted.

The floating capacity Cs can be easily adjusted by the position and size of the concave portion 30.

(Thirdteenth Embodiment)

Fig. 22 is an embodiment 13, where a concave portion 31 of approximately L type in a stage shaped section, instead of such a taper shaped section as in the prior embodiment, is formed on the single side of the corner portion on the top face of the dielectric 22. Even in this case, the interval between the inside conductor 24 within the hole 23 and the outside conductor 25 which becomes an earth electrode of the concave stage portion 31 becomes shorter so that the floating capacity Cs can be easily obtained.

Although the concave stage portion 31 is continuously formed in Fig. 22, it may be formed not continuously, in one portion or intermittent portions, in the corner portions on both the side portions of the dielectric 22. The size of the floating capacity can be easily adjusted by the size or the like of the concave stage portion 31.

(Fourteenth Embodiment)

The present embodiment 14 in Fig. 23 and Fig. 24 is an embodiment where the concave stage portion 31 is further made deeper as compared with the case of the above described embodiment 18. In an integrated type of dielectric resonator, the floating capacity Cs is obtained by the inside conductor 24 and the concave stage portion 31 is formed by a dielectric filter comb-line connected so that the outside conductor 25 is approached to the inside conductor 24 within the hole 23 so as to increase the floating capacity Cs.

The approached size W and the depth X of the concave stage portion 31 are adjusted so as to adjust the coupling. When the size of the dielectric 22 in the axial direction of the hole 23 is made L, $0 \leq X < L$.

The coupling coefficients of the dielectric resonator can be changed by the change in the above described size X, W so that the passing band of the filter can be controlled without the shape (metal mold).

The shape of the dielectric resonator can be standardized, and the metallic cost and the management cost can be reduced.

As the large coupling coefficient can be obtained without the pitch between the holes 3 being narrowed, the pole of the high pass becomes far from the passing band, and the damping of the low pass is improved. The resonance electrode length becomes shorter with the floating capacity Cs being increased, so that the filter can be made smaller in size. Further, the filter larger in the specific band is obtained.

The dielectric resonator in each of the above described embodiments is not restricted to the number of the stages although the three-stage construction has been described. Namely, it can be applied to the dielectric resonator of one stage or three-stage or more.

The dielectric resonator of the present invention can be applied to a case where all the filters such as band pass filter, band elimination filter, high-pass filter, low-pass filter and so on are formed.

As is clear from the foregoing description, according to the arrangement of the present invention, the dielectric resonator of the present invention can be mounted on the surface on the circuit basic plate without the use of a special individual signal input, output terminals as the signal input, output electrodes are provided on one portion of the external conductor. As the conductor exists on the open face of the internal conductor formed hole so as to provide no open face, the electromagnetic field leakage is less so that influences by he electromagnetic field leakage are less if the dielectric resonator is mounted on the circuit basic plate in a condition as it is.

According to the dielectric resonator of the present invention, a dielectric resonator without coupling coefficients being adjusted between the resonator frequency of the resonator and the resonance without coating addition and so on with respect to the non-formed portion of the internal conductor.

According to the dielectric resonator of the present invention, the open portion of the internal conductor is formed in a location secluded from the open face of the internal conductor formed holes, the influences by the electromagnetic field leakage is less. Therefore, no couplings among the resonator, the other object near the resonator and the circuit are provided so that stable resonator characteristics are provided.

As is clear from the characteristic adjusting method of the dielectric resonator of the present invention, there are steps of providing an open portion in one portion of the internal conductor only by the movement of a grinding tool in the axial direction of the internal conductor formed hole with the deletion locations of the internal conductor and the dielectric being restricted, and also, easily adjusting the tip end capacity by the moving amount. Further, a dielectric resonator having given resonance frequency and coupling amount can be easily obtained without the higher size accuracy to be demanded in the grinding working operation, because the tip end capacity is gradually lowered in spite of much grinding amount of the whole.

In a dielectric resonator for making resonant with the given frequency by an inside conductor formed on the inside face of the hole of the dielectric and an outside conductor formed on the outside face of the above described dielectric, the concave portion is formed on the surface of the above described dielectric, the outside conductor of the bottom portion of the concave portion is approached to the above described inside conductor so that the interval between the inside conductor of the hole interior of the dielectric and the outside conductor which becomes an earth electrode becomes shorter so as to easily obtain the floating capacity by the approaching operation between the outside conductor of the bottom portion of the concave portion formed on the surface of the dielectric and the above described inside conductor. The floating capacity can be adjusted by the comparatively simple working or molding operation of the size, depth and so on of the concave portion. In the comb-line type, the band width of the filter can be made larger by provision of, for example, larger floating capacity. Resonator length becomes shorter by the provision of, for example, the larger floating capacity with an effect that the size may be made smaller.

In the present invention, the taper portion is formed in the corner portion of the dielectric, and the outside conductor of the taper portion is approached to the inside conductor, the interval between the inside conductor of the hole interior of the dielectric and the outside conductor which becomes an earth electrode becomes shorter as in the case of the claim 1 so that the floating capacity is easier to obtain. The floating capacity can be adjusted by comparatively simple working or molding operation of the size, inclination and so on of the taper portion of the corner portion. In the comb-line type, the band width of the filter can be made larger by the provision of, for example, the larger floating capacity. The resonator length becomes shorter by provision of, for example, the larger floating capacity so that the size may be made smaller.

In the present invention, approximately L type of concave stage portion in section is provided in the corner portion of the dielectric, and the outside conductor of the concave stage portion is approached to the inside conductor so that the interval between the inside conductor of the hole interior of the dielectric and the outside conductor which becomes an earth electrode becomes shorter so as to easily obtain the floating capacity. The floating capacity can be adjusted by comparatively simple working or molding operation of the size, depth and so on of the concave portion of the corner portion. In the comb-line type, the band width of the filter can be widened by provision of, for example, the larger floating capacity. The resonator length becomes shorter by provision of, for example, the larger floating capacity so that the size may be made smaller.

In the present invention the non-conductive portions may be spaced unequally from the ends of the holes and they may have unequal axial lengths.

The construction of the dielectric resonator in accordance with a further embodiment where the resonance frequency and the coupling degree have been adjusted by the provision of the deletion portion of the conductor and the dielectric in one portion of the short-circuit face is shown in Fig. 25. Fig. 25 is a front face view seen from the short-circuit face side, with reference characters C, D being deletion portions of the conductor and the dielectric of the short-circuit faces. The resonance frequency of the resonator by the internal conductor formed hole 5 is lowered by the partial deletion of the conductor and the dielectric in the region of the SI in Fig. 25. Similarly, if the conductor and the dielectric are partially deleted in the region of the S2, the resonance frequency of the resonator is lowered by the internal conductor formed hole 6. The coupling degree between both the resonators is lowered if the conductor and the dielectric are partially deleted in the region of the S12. Modified embodiment of the coupling coefficients by the deletion of the conductor and the dielectric are shown in Fig. 26 and Fig. 28. A conductor deletion portion of a width d is provided in the middle position of two coupling holes as shown in Fig. 26. Changes in the coupling coefficients are measured when the area S has been changed. In Fig. 26, a = 2.0 mm, b = 4.0 mm, c = 5.0 mm. Fig. 28 shows the change ratio of the coupling coefficients with the axis of abscissas being a conductor deletion area S, the axis of ordinates being Ko in the coupling coefficient in the case of S = 0, the coupling coefficient after the conductor deletion being Ka. The coupling coefficient can be adjusted by the conductor deletion area among the internal conductor formed holes on the short-circuit face. Fig. 27 and Fig. 28 show the adjustment example of the resonance frequency. A conductor deletion portion of a length g with a width f is provided in a location away at a given interval from the internal conductor formed hole as in Fig. 27 so as to measure the resonance frequency when the length g has been changed. In Fig. 27, a = 2.0 mm, e = 3.0 mm, f= 0.5 mm. In Fig. 29, the axis of abscissas is a length g, the axis of ordinates shows the variation amount in the resonance frequency with the resonance frequency in the case of g = 0 being a reference. The resonance frequency can be adjusted by the conductor deletion of the internal conductor formed periphery on the short-circuit face.

A embodiment shown in Fig. 25 through Fig. 29 is that one portion of the conductor and the dielectric is deleted on the short-circuit face, and the capacity Cs is decreased, if the conductor and the dielectric on the open face on the internal conductor non-formed portion side are deleted, so that the resonance frequency can be adjusted in a higher direction.

Although two stages of dielectric resonator is shown in the examples shown in Fig. 25 through Fig. 29, the same things can be applied even to the dielectric resonator of three stairs or more. The coupling degree between the resonators are adjusted by the partial deletion of the conductor and the dielectric in the area S12, S23, ... $S_{n-1\ n}$ among the open portions of the internal conductor formed holes on the short-circuit face as described in Fig. 30 in this case. The resonance frequency of the respective resonators can be adjusted by the partial deletion of the conductor and the dielectric in the regions of S1, S2, S3 ... Sn.

Claims

1. Dielectric resonator comprising

a dielectric body (1; 21) having at least one through hole (5,6);

an internal conductor (2,3) formed on the inside of said at least one through hole (5,6); and

an external conductor (4) formed on the outside face of the dielectric body (1);
characterized in that
said at least one through hole (5,6) has at least two sections of same diameter and an adjustment portion (A;B;15) free of internal conductor having a diameter different from the diameter of said at least two sections, thus separating said at least two sections by a non-conductive portion, wherein said diameter of said adjustment portion (A;B;15) free of internal conductor is larger than said diameter of said at least two sections.

2. The dielectric resonator as claimed in claim 1, comprising a plurality of holes.

3. The dielectric resonator as claimed in claim 1 or 2, wherein the dielectric body (1) is a rectangular block, an outer surface of the dielectric body being defined by at least one face being a circuit base plate mounting face for mounting and electrically connecting the dielectric resonator to a circuit base plate, signal input and output electrodes (9,10) being provided on said at least one face of said outer surface of the dielectric body.

4. The dielectric resonator as claimed in any of the claims 1 to 3, wherein an outer surface of the dielectric body (1) defines a face and respective side faces, signal input and output electrodes (9, 10) being on the face of said outer surface and extend from the face to said respective side faces of the dielectric body (1).

5. The dielectric resonator as claimed in any of the claims 1 to 3, wherein at least two said holes (5, 6) have a respective pair of internal conductor sections separated by a corresponding non-conductive portion (A;B;15).

6. The dielectric resonator as claimed in claim 5, wherein said non-conductive portions (A;B;15) are spaced unequally from the ends of the holes.

7. The dielectric resonator as claimed in claim 6, wherein said non-conductive portions (A;B;15) have unequal axial lengths.

8. The dielectric resonator as claimed in any of the claims 1 to 3 further comprising a short-circuit face, a portion of the external conductor being removed in one portion of the short-circuit face for adjusting at least one of the resonance frequency and the coupling degree of the resonator.

9. The dielectric resonator as claimed in any of the claims 1 to 3 further comprising a short-circuit face, a portion of the dielectric body being removed in one portion of the short-circuit face for adjusting at least one of the resonance frequency and the coupling degree of the resonator.

10. The dielectric resonator as claimed in any of the claims 1 to 3, wherein the dielectric body (21) includes an end face, a pair of recesses (28) in the dielectric body at the end face thereby defining a pair of side portions of the end face, the recesses being generally parallel with the side portions and being located on respective sides of the plurality of holes (23).

11. The dielectric resonator as claimed in any of the claims 1 to 3, wherein the dielectric body (21) includes a side face, a recess (28) in the dielectric body at the side face.

12. The dielectric resonator as claimed in any of the claims 1 to 3, wherein the dielectric body (21) includes a side face, a recess (28) in the dielectric body at the side face, the external conductor extending into the recess in the dielectric body and over a bottom surface of the recess.

13. The dielectric resonator as claimed in any of the claims 1 to 3, further comprising a plurality of generally circular recesses (28) at locations proximate to the plurality of holes (23), the generally circular recesses extending into the dielectric body in the same direction as the plurality of holes.

14. The dielectric resonator as claimed in any of the claims 1 to 3, wherein the dielectric body (21) includes a side face, a generally circular recess (28) in the dielectric body at the side face, the external conductor extending into the generally circular recess in the dielectric body and over a bottom surface of the recess, a portion of the external conductor on the bottom surface of the generally circular recess being generally parallel to the internal conductor in a corresponding one of the plurality of holes.

15. The dielectric resonator as claimed in any of the claims 1 to 3, wherein the dielectric block (21) comprises a shaped portion (29), said shaped portion (29) of the dielectric block (21) comprising tapered portions provided on at least one corner of the dielectric block so that portions of the external conductor on the tapered portions are closer to the internal conductors in the plurality of holes.

16. The dielectric resonator as claimed in any of the claims 1 to 3, wherein the dielectric block (21) comprises a shaped portion (31), said shaped portion of the dielectric block comprising stepped portions of generally L-shape provided on at least one corner of the dielectric block so that portions of the external conductor on the stepped portions are closer to the internal conductors in plurality of holes.

17. Method for adjusting the tip end capacity of a dielectric resonator comprising

a dielectric body (1) having at least one through hole (5,6);

an internal conductor (2,3) formed on the inside of said at least one through hole (5,6) said through hole having at least two sections of same diameter; and

an external conductor (4) formed on the outside face of the dielectric body (1);
characterized by the step of

grinding an adjustment portion (A;B;15) free of internal conductor having a diameter different from the diameter of said at least two sections, thus separating said at least two sections by a non-conductive portion, wherein said diameter of said adjustment portion (A;B;15) free of internal conductor is larger than said diameter od said at least two sections.

18. The method as claimed in claim 17, wherein the step of grinding comprises removing the internal conductor from said adjustment portion.

19. The method as claimed in claim 17 or 18, wherein the step of grinding comprises removing a predetermined amount of dielectric material and the internal conductor from said adjustment portion.

Fig. 1

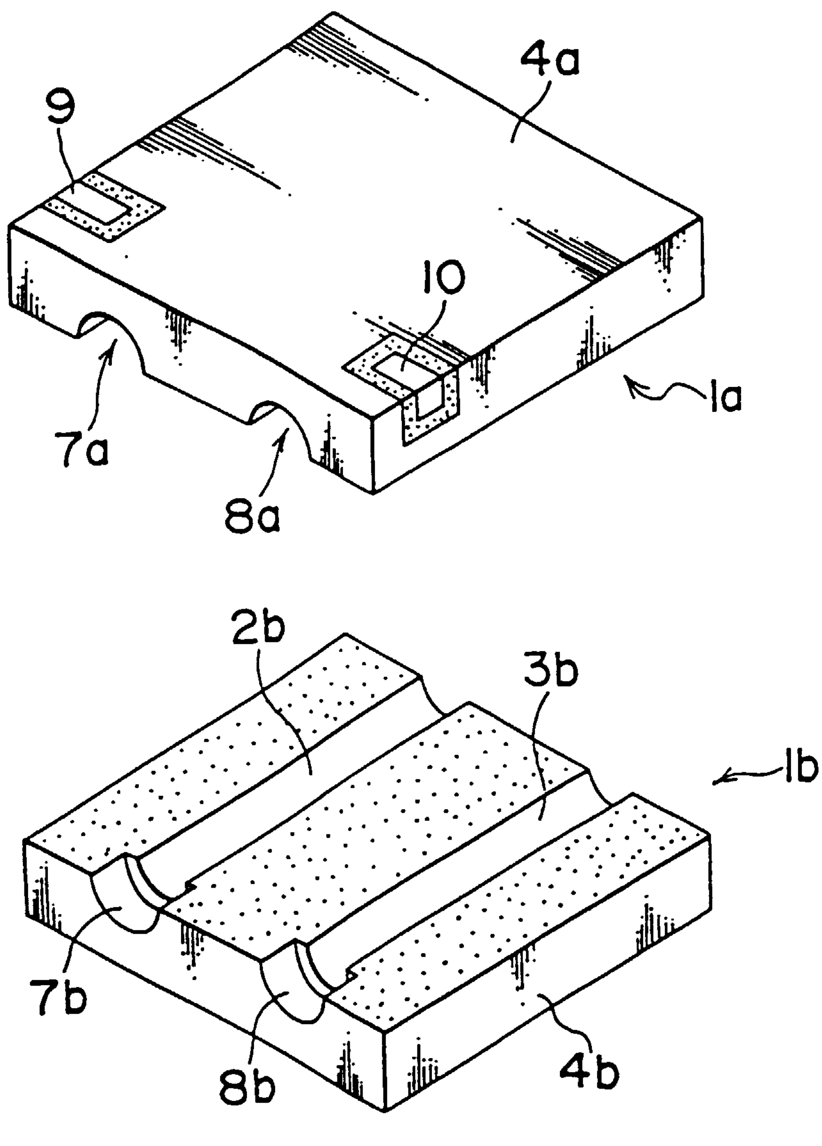


Fig. 2

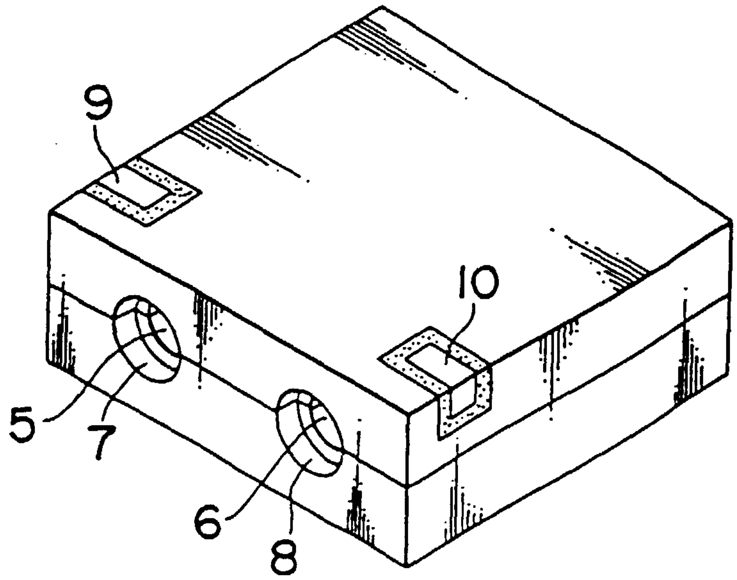


Fig. 3

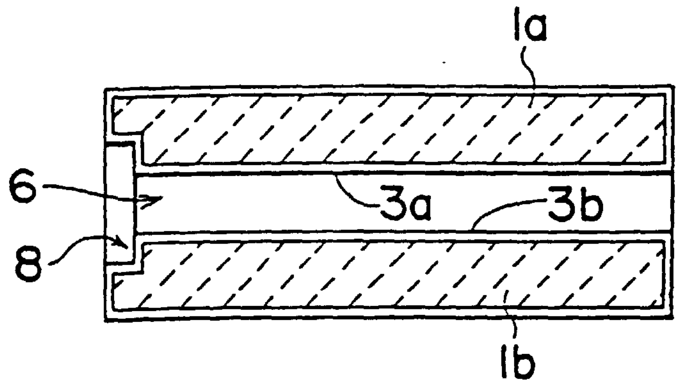


Fig. 4

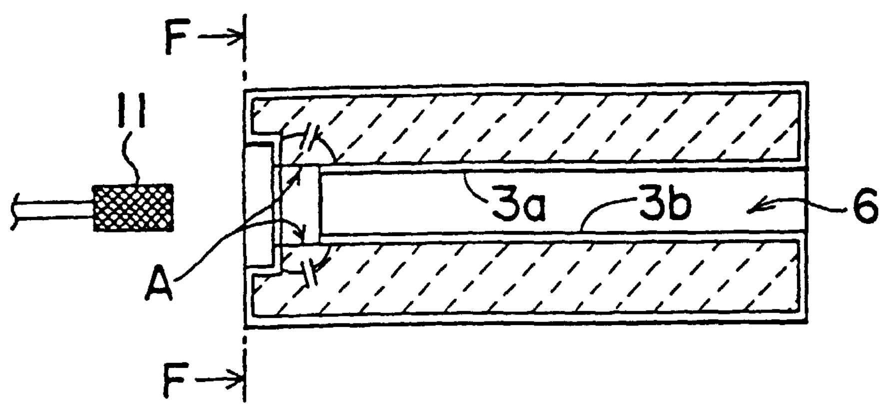


Fig. 5

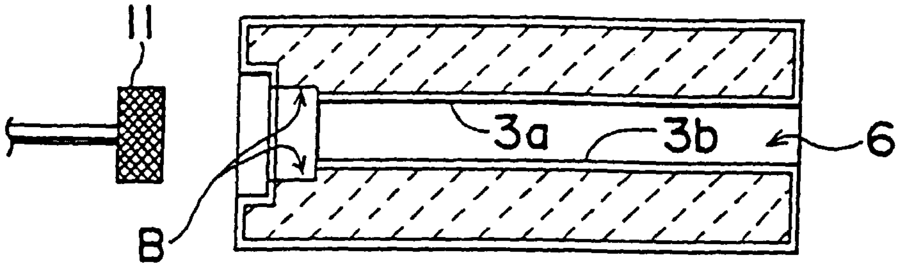


Fig. 6

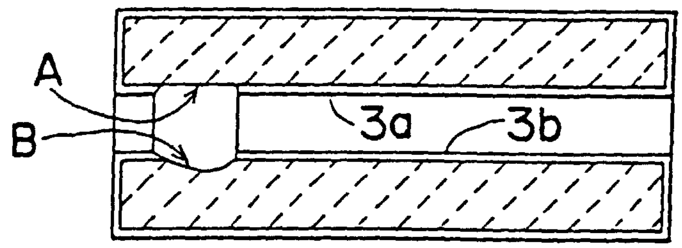


Fig. 7

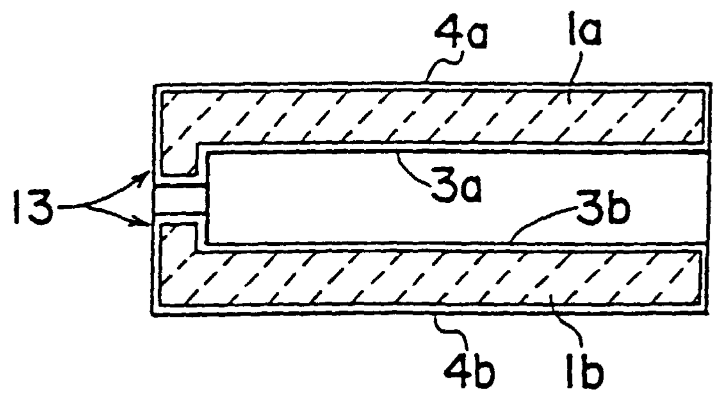


Fig. 8

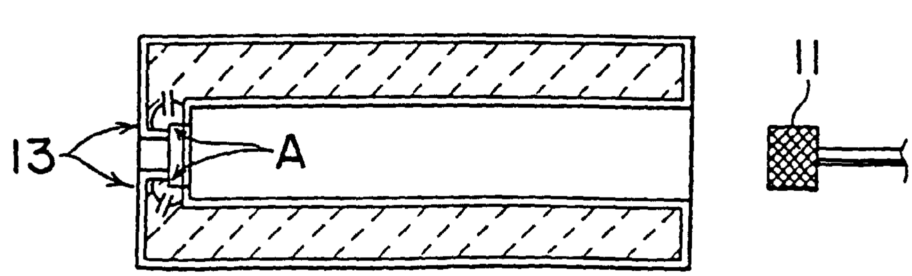


Fig. 9

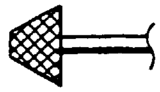


Fig. 10

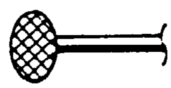


Fig. 11

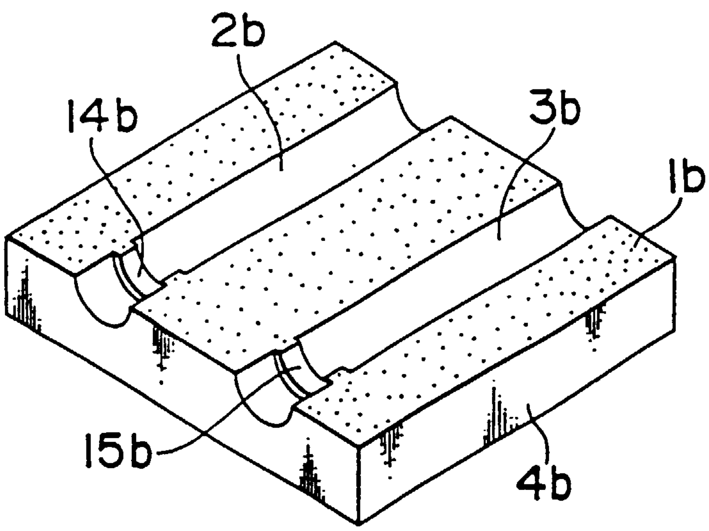


Fig. 12

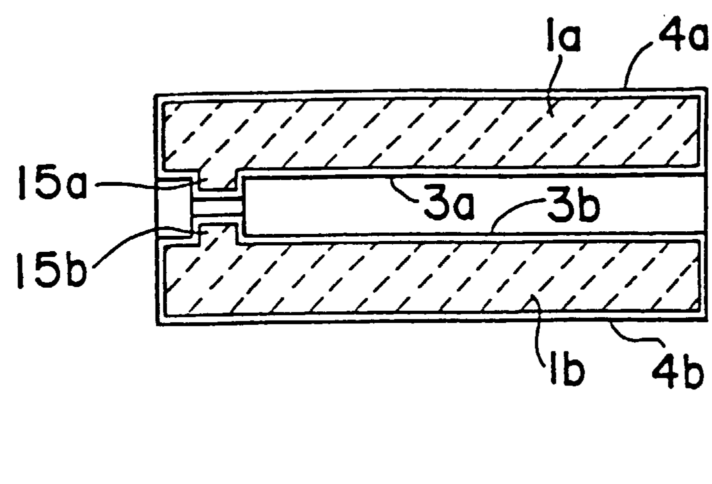


Fig. 13

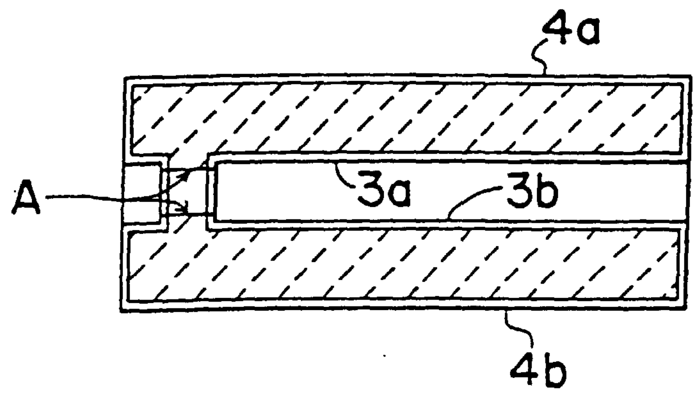


Fig. 14(a) 4(a)

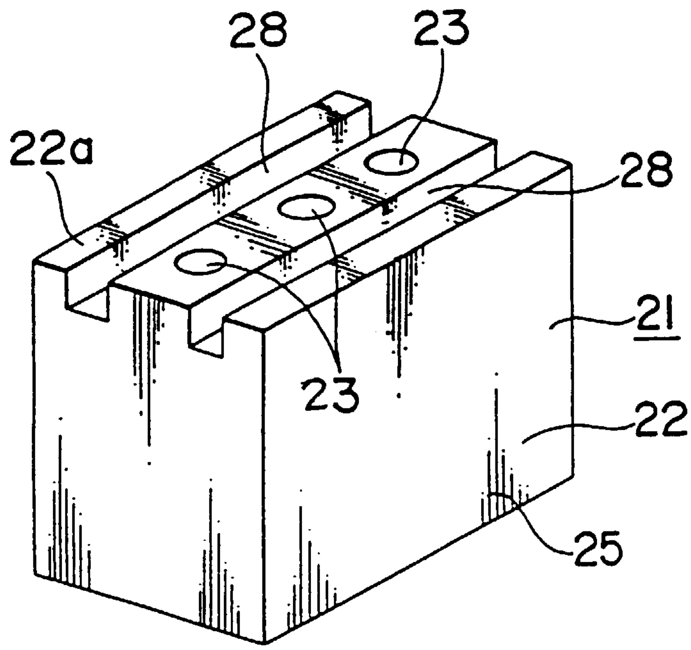


Fig. 14(b) 14(b)

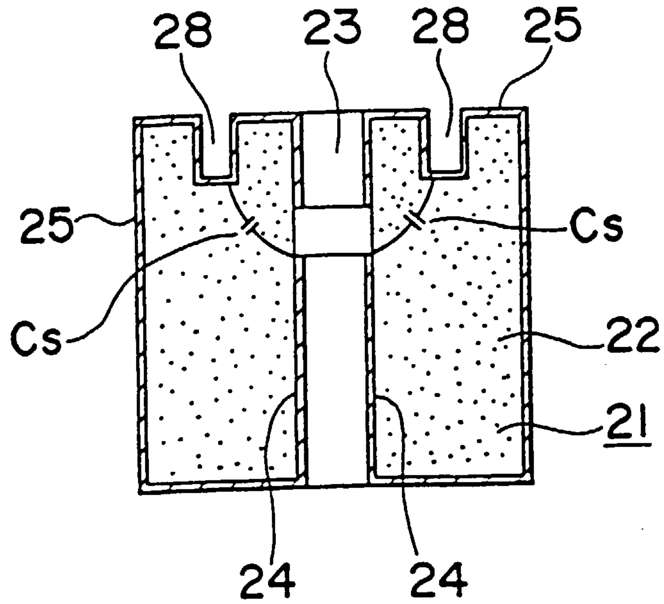


Fig. 15

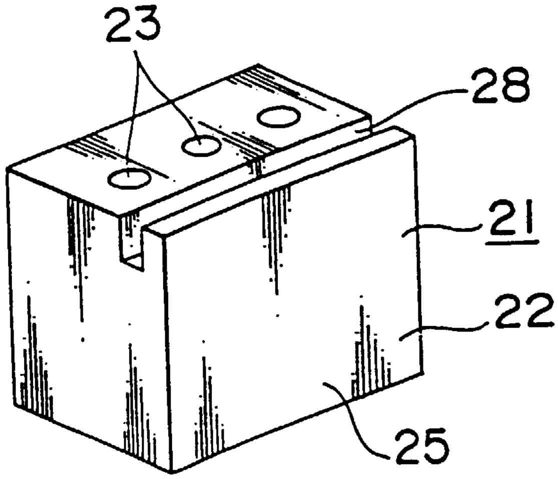


Fig. 16(a) '6 (a)

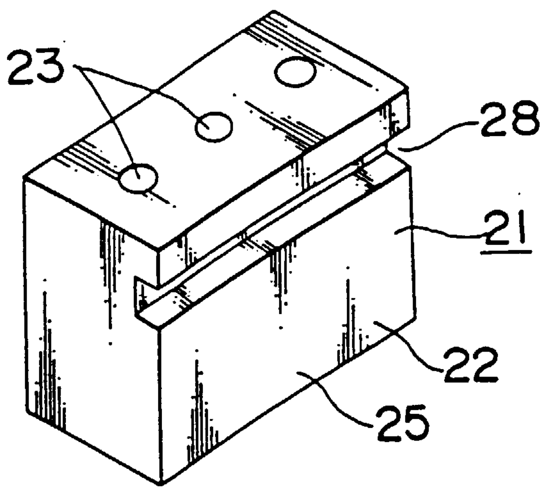


Fig. 16(b)

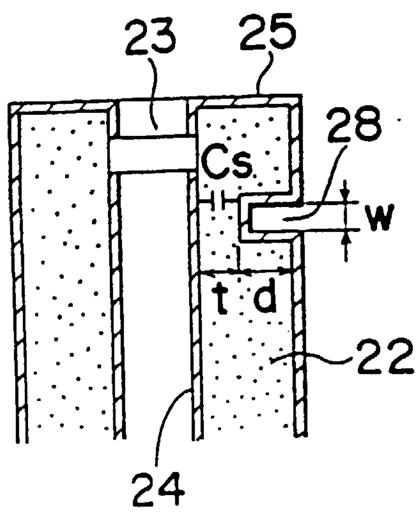


Fig. 17(a)

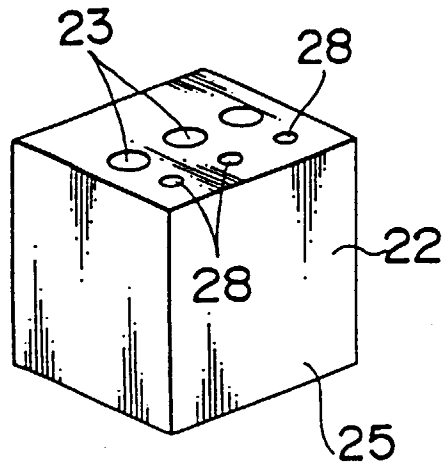


Fig. 17(b)

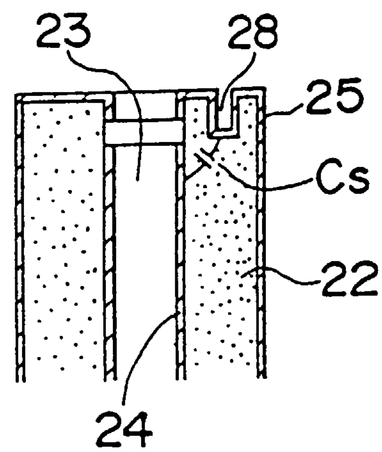


Fig. 18(a)

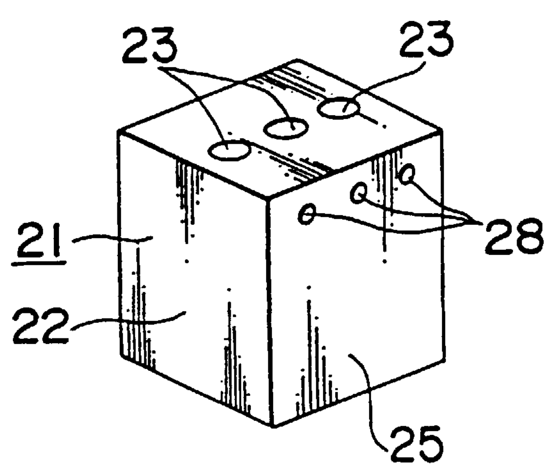


Fig. 18(b)

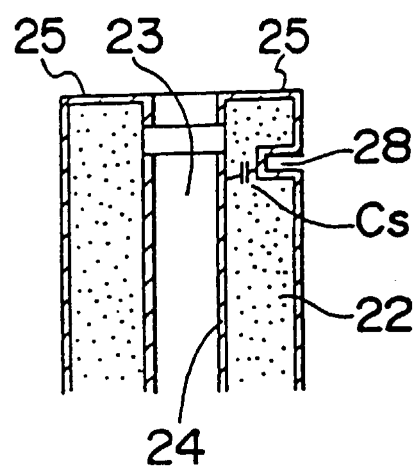


Fig. 19(a)

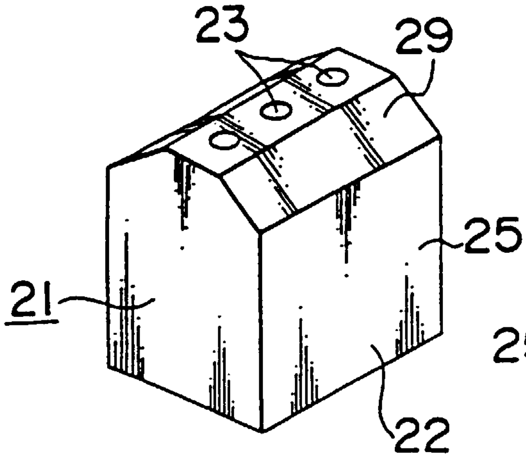


Fig. 19(b)

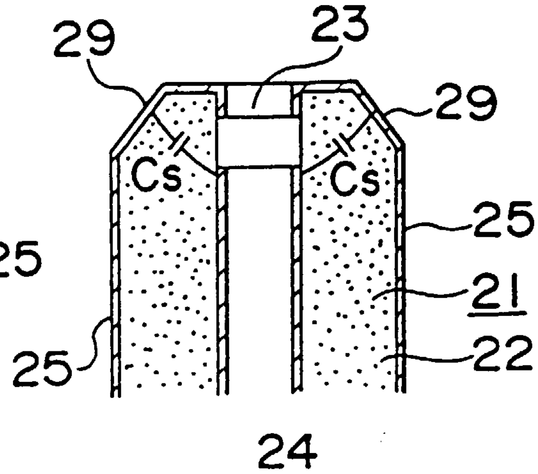


Fig. 20

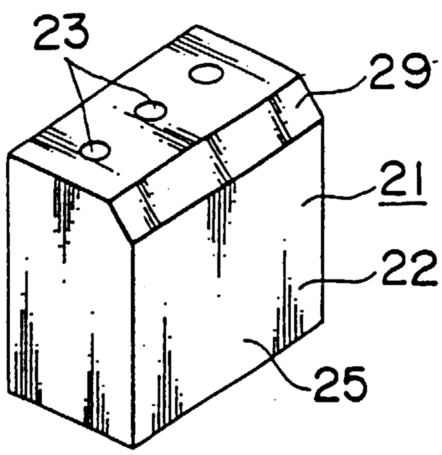


Fig. 21

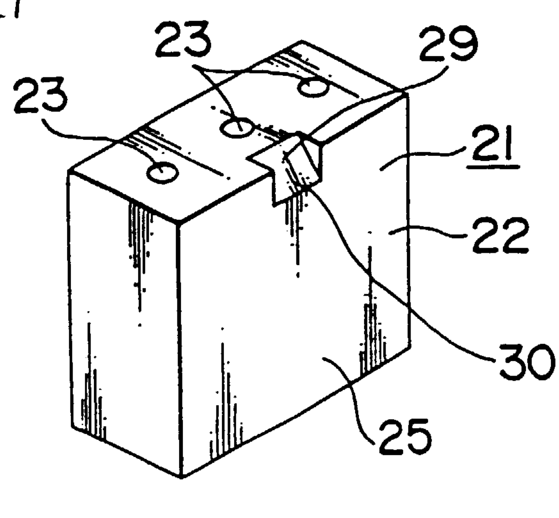
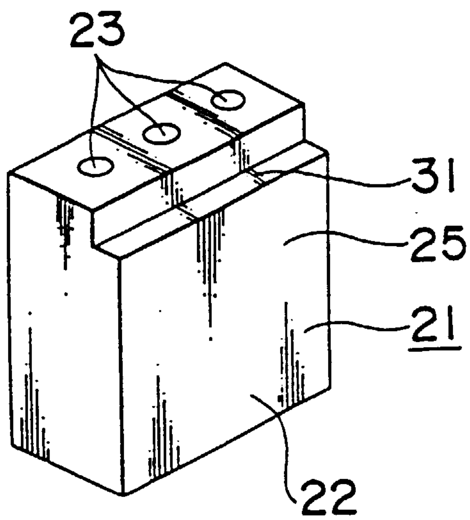


Fig. 22



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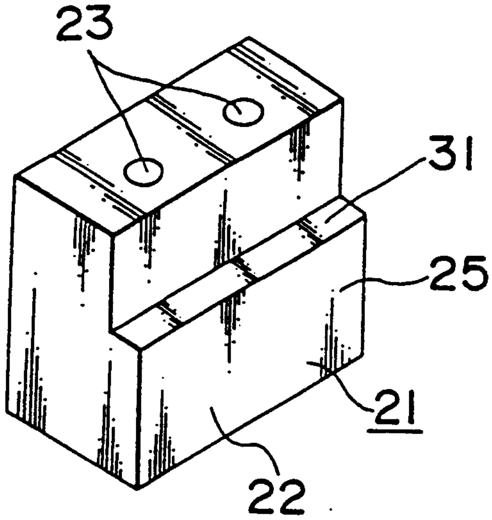


Fig. 24

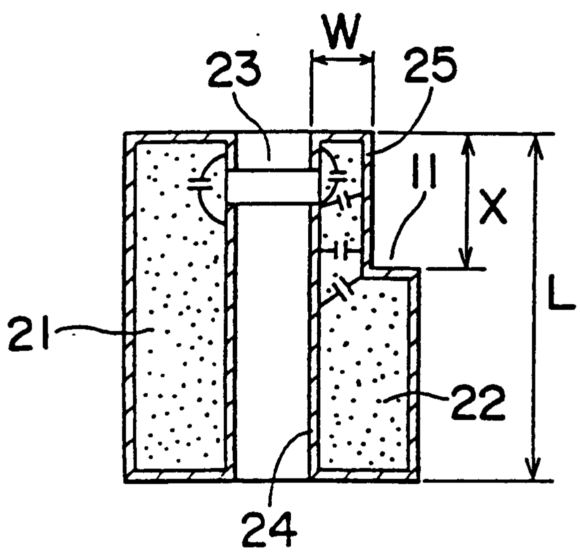


Fig. 25

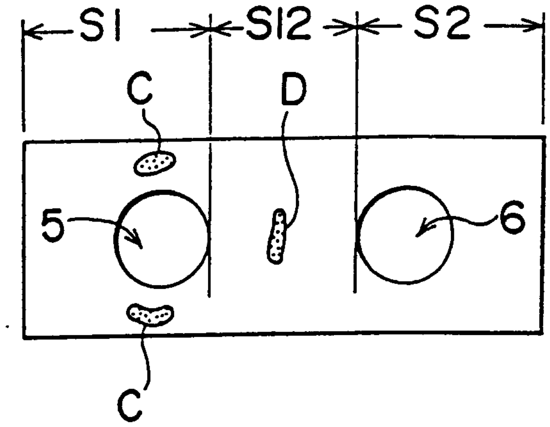


Fig. 26

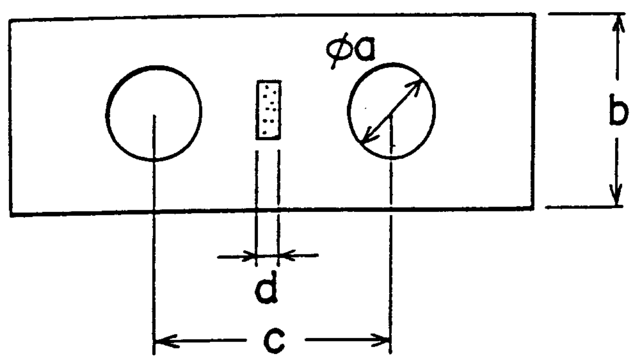


Fig. 27

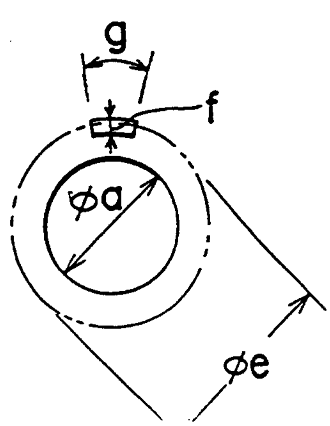


Fig. 28

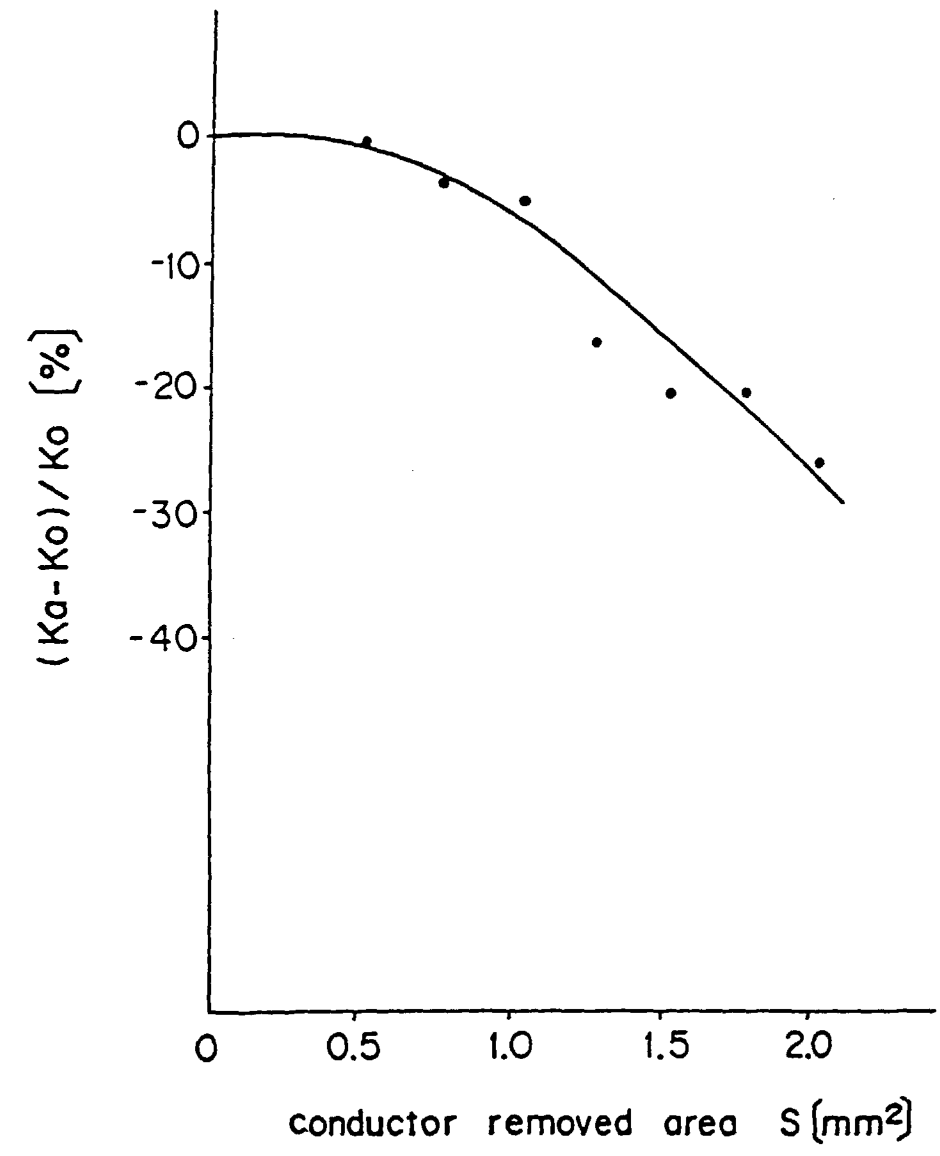


Fig. 29

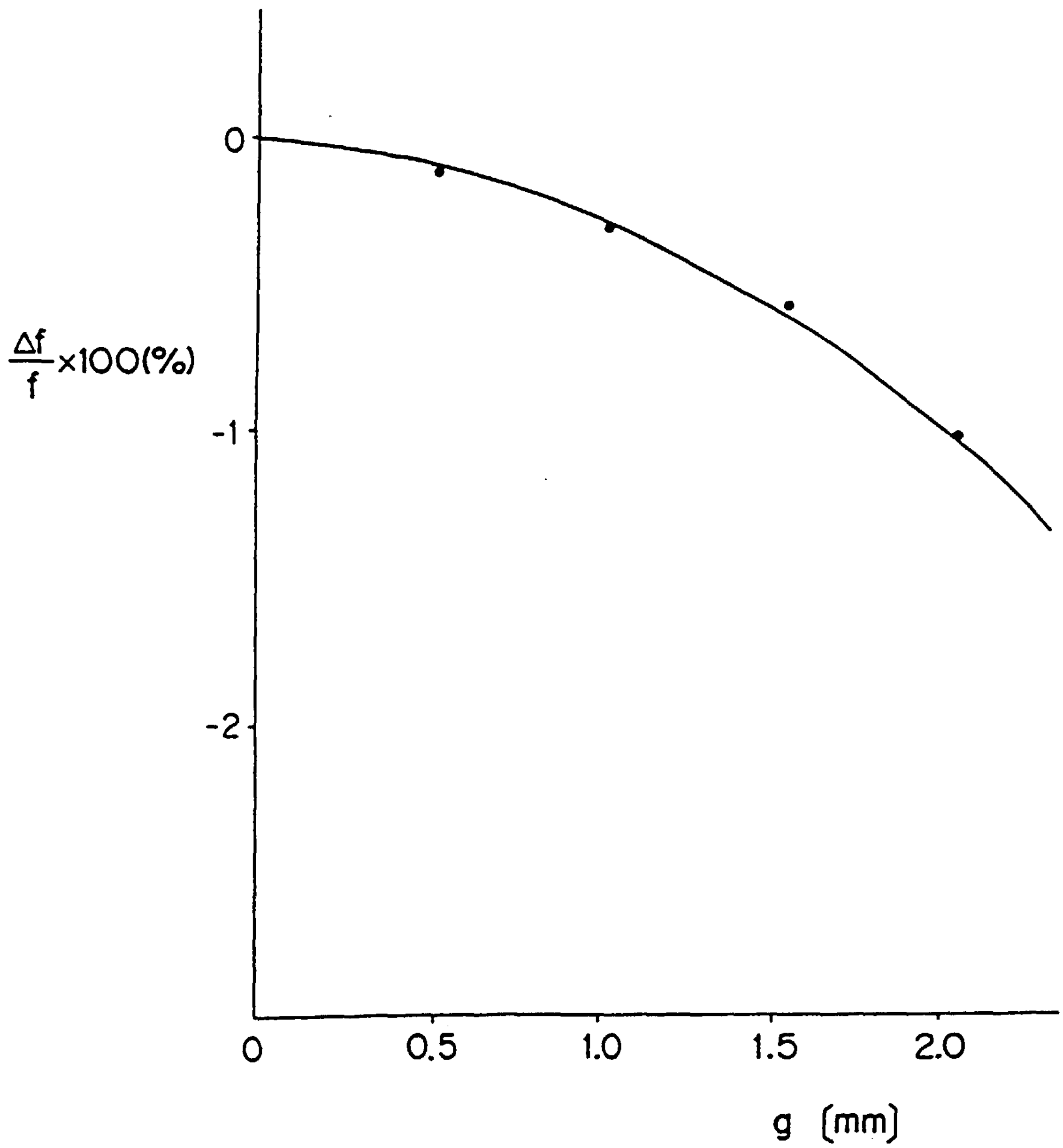
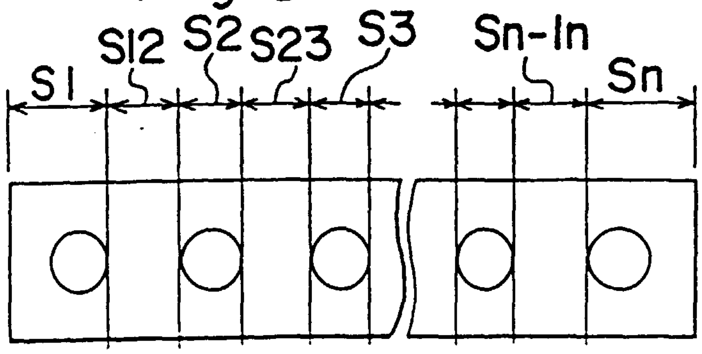


Fig. 30



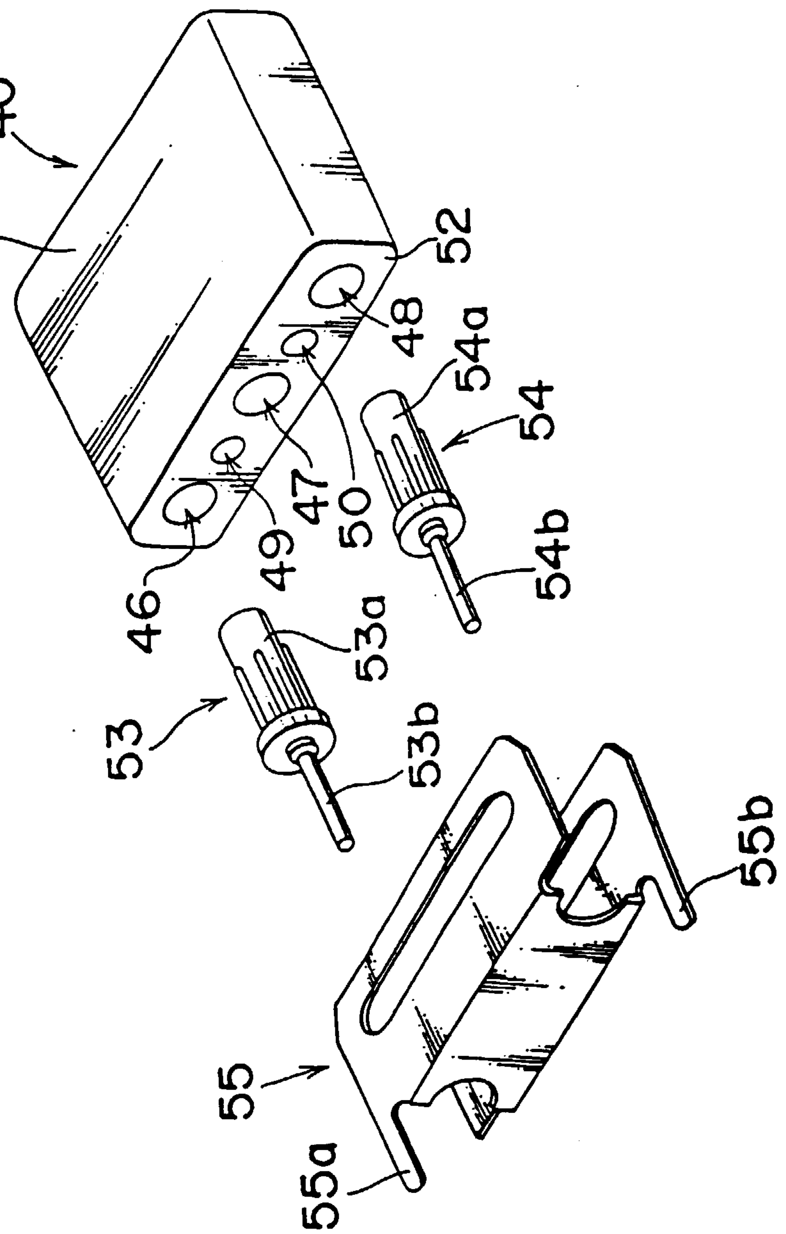


Fig. 31 PRIOR ART

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 98 10 4197

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	WO 83 02853 A (MOTOROLA INC) 18 August 1983 * page 4, line 1 - page 5, line 29; figures 1,4 * ---	1	H01P1/205
A	GB 2 240 432 A (NGK SPARK PLUG CO LTD) 31 July 1991 * page 3, line 32 - page 4, line 20; figure 2 * ---	1	
A	PATENT ABSTRACTS OF JAPAN vol. 6, no. 72 (E-105) [950] , 7 May 1982 & JP 57 013801 A (NIPPON DENGIYOU KOUSAKU K.K.), 23 January 1982, * abstract * ---	1	
A	WO 85 00929 A (AMERICAN TELEPHONE & TELEGRAPH COMP.) 28 February 1985 * the whole document * ---	1	
A	GB 2 163 606 A (MURATA MANUFACTURING CO LTD) 26 February 1986 * page 4, line 57 - line 63 * * page 5, line 50 - page 6, line 18; figures 8,13-15 * -----	1	TECHNICAL FIELDS SEARCHED (Int.Cl.6) H01P

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	29 April 1998	Den Otter, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
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P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
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